Year: 2012

Estimation bias: body mass and body height in endurance athletes

Knechtle, B ; Rüst, C A ; Rosemann, T ; Knechtle, P ; Bescos, R

Abstract: Body Mass Index is associated with endurance performance in athletes. Reported and measured values of body mass and body height in 1,607 endurance athletes (1,352 men, 255 women) showed that men and women both underestimated their body mass and overestimated their body height, leading to an underestimation of Body Mass Index. There were age and sex differences in estimates of height and weight; for both women and men, underestimation of Body Mass Index amounted to 0.4 kg/m2. Master athletes tended to underestimate their body mass and overestimate their body height thus leading to significant differences between estimated and measured Body Mass Index. However, the magnitude of underestimation of BMI probably has a negligible influence on performance predictions. The differences between measured and estimated body mass, height, and BMI were within the range of normal daily variation, and for body height even within the precision of the measurement (0.5 cm).

DOI: https://doi.org/10.2466/03.27.PMS.115.6.833-844

Originally published at:
Knechtle, B; Rüst, C A; Rosemann, T; Knechtle, P; Bescos, R (2012). Estimation bias: body mass and body height in endurance athletes. Perceptual and Motor Skills, 115:833-844.
DOI: https://doi.org/10.2466/03.27.PMS.115.6.833-844

ESTIMATION BIAS: BODY MASS AND BODY HEIGHT IN ENDURANCE ATHLETES

BEAT KNECHTLE, CHRISTOPH ALEXANDER RÜST, THOMAS ROSEMANN

Institute of General Practice and Health Services Research,
University of Zurich, Zurich, Switzerland

PATRIZIA KNECHTLE

Gesundheitszentrum St. Gallen,
St. Gallen, Switzerland

RAUL BESCOS

Physiology Laboratory of National Institute of Physical Education (INEFC),
University of Barcelona, Barcelona, Spain

1 Address correspondence to Beat Knechtle, M.D., Facharzt FMH für Allgemeinmedizin, Gesundheitszentrum St. Gallen, Vadianstrasse 26, 9001 St. Gallen, Switzerland or e-mail (beat.knechtle@hispeed.ch)

Summary.—Body mass index is associated with endurance performance in athletes. Reported and measured values of body mass and body height in 1,607 endurance athletes (1,352 men and 255 women) showed that men and women both underestimated their body mass and overestimated their body height, leading to an underestimation of body mass index. There were age and sex differences in estimates of height and weight; for both women and men, underestimation of body mass index amounted to 0.4 kg/m^2. Master athletes tended to underestimate their body mass and overestimate their body height thus leading to significant differences between estimated and measured body mass index. However, the magnitude of underestimation of BMI probably has a negligible influence on performance predictions. The differences between measured and estimated body mass, height, and BMI were within the range of normal daily variation, and for body height even within the precision of the measurement (0.5 cm).

In recent years, several studies investigated the association between anthropometric characteristics and performance in endurance athletes (Aagaard, Sahlen, & Braunschweig, 2012; Arrese & Ostáriz, 2006; Bale, Bradbury, & Colley, 1986; Hagan, Upton, Duncan, & Gettman, 1987; Hoffman, 2008; Hoffman & Fogard, 2011; Kenney & Hodgson, 1985; Knechtle, Duff, Welzel, & Kohler, 2009a; Knechtle et al., 2011a; Knechtle, Knechtle, Barandun, Rosemann, & Lepers, 2011b). Different anthropometric characteristics showed a significant relationship with endurance performance, although the correlations between them and performance were consistently quite small, ranging from under r = .04 to an upper bound of r = .52, that is, from essential zero to 11% of the variance in performance. Among these anthropometric characteristics, body mass index has accounted for roughly 25% of the variance in performance (Aagaard, Sahlen, & Braunschweig, 2012; Hagan, Upton, Duncan, & Gettman, 1987; Hoffman 2008; Hoffman & Fogard, 2011; Rüst, Knechtle, Knechtle, Barandun, Lepers, & Rosemann, 2012; Zillmann, Knechtle, Rüst, Knechtle, Rosemann, & Lepers, 2013).

Apart from the different distances and disciplines the athletes were competing, also the method to calculate body mass index differed, comprising either a self-report (Hoffman & Fogard, 2011) or measurement of body mass and body height of the athletes pre-race (Hoffman 2008; Hoffman et al., 2010; Knechtle, *et al.,* 2010d, 2010e) to calculate body mass index. Body mass and body height vary during the day. It is a concern that BMI calculated from reported values of body mass and body height might lead to significant errors compared to measured values due to differences in timing of measurements or errors in recall.

Differences between calculated and estimated body height and body mass were examined, to assess potential errors in body mass index and its use as a predictor of performance. It was hypothesized that estimations of body mass index from self-report of body mass and body height of athletes may differ from data gathered using a standardized measurement procedure. Given the differing emphasis on weight in particular between men and women, and also in various sport disciplines, differences in accuracy of estimations were predicted.

METHOD

Participants

Between 2006 and 2011, body mass and body height were measured both by self-report and by standardized objective procedures pre-race in 1,607 recreational endurance athletes (1,352 men, 255 women) to calculate body mass index (BMI). These athletes participated in swimming (*n*=69), cycling (*n*=230), running (*n*=846), triathlon (*n*=350) and inline skating (*n*=112) events (Table 1). Self-report data were compared with measured values. Ethical approval was granted for each event by the Institutional Review Board of the Canton of St. Gallen, Switzerland.

Kommentar [SI1]: Table 1

Measurements and Calculations

Athletes appeared for the pre-race measurements the afternoon of the day before the start of the race and completed a questionnaire which included a request for estimated body mass and body height. Anthropometric measurements were performed the day before the races and were conducted by the same investigators in all races using the same equipment. Body mass was measured to the nearest 0.1 kg using an electronic scale (Beurer, Ulm, Germany) after voiding the bladder. The athletes took off their race garments and body mass was measured while standing in their underwear on the scale. Body height was measured using a stadiometer to the nearest 0.5 cm without wearing shoes.

Statistical Analyses

Body mass, body height and body mass index by gender and age were assessed to assess the normality of the distribution using the Kolmogorov-Smirnov test. To compare differences between body mass, body height and body mass index reported by athletes and data obtained by the measurements of researchers, a non-parametric Wilcoxon test was used. In addition, the clinical effect of difference between data reported by athletes and measured by researchers was assessed using Cohen's *d* and intraclass coefficient correlation (ICC). The significance level was set at $p < .05$. Statistical analysis was performed using SPSS Version 15.0 (SPSS, Inc., Chicago, IL).

RESULTS

Athletes' Self-report Versus Researchers' Measurements

The descriptive statistics for body mass, body height and body mass index reported by athletes and measured by researchers are shown in Tables 2, 3, and 4. Both men ($t_{2715} = -2.58$, $p = .008$, Cohen's $d = 0.10$) and women ($t_{509} = -1.17$, $p < .001$, Cohen's $d = 0.12$) underestimated significantly their body mass (Table 2). On the contrary, both men ($t_{2715} = 1.35$, $p < .001$, Cohen's $d = 0.05$) and women ($t_{509} = 0.70$, $p < .001$, Cohen's $d = 0.06$) overestimated significantly their body height (Table 3). Similarly to body mass, both men ($t_{2715} = -4.33$, $p < .001$, Cohen's $d = -0.23$) and women ($t_{509} = 79.03$, $p < .001$, Cohen's $d = -0.18$) underestimated significantly their body mass index (Table 4). Range of agreement between data reported by athletes and data collected by researchers was very high showing scores of ICC > .94 (Tables 2-4).

Kommentar [SI2]: Tables 2, 3, 4

Comparison Between Sport Groups

Male triathletes reported more accurate data for body height compared to cyclists (Cohen's $d = -0.07$), runners ($d = 0.05$) and line skaters ($d = -0.05$). In women, triathletes reported also more accurate body height in comparison to runners ($d = 0.09$) and swimmers (*d*

= 0.16). There were no differences in the other parameters between the sport groups (Table 3).

Comparison Between Age Groups

A comparison between age groups showed that older men (> 35 years) significantly underestimated both their body mass (d = -0.08) and body mass index (d = -0.14) compared to younger men (< 35 years). In contrast, no significant differences were found between older and younger women.

Distribution of BMI Classifications

A higher percentage of self-reports from men (12.4%; chi-square = 35.68; n = 167) compared to women (5.2%; n = 14; p < .001) led to misclassification by World Health Organization standards for body mass index (Table 5). A significant number of men (6.2%; χ^2= 33.35; n = 83; p < .001) indicated that their body mass index was within the normal range while they were classified as overweight by objective measures. Comparing objective data between women and men, almost all women had body mass index within the range of underweight (5.4%; χ^2= 3.98; n = 14) or normal weight (86.2%; n = 224), statistically different from classifications of men since 24.4% (χ^2= 35.68; n = 332; p < .001) of men were classified as overweight.

Kommentar [SI3]: We assume this is completely due to large muscle mass?

DISCUSSION

The aim of this study was to compare reported data for body mass and body height with objective measures collected using a standardized procedure. The main findings of this study were that both women and men underestimated their body mass compared with values obtained directly by measures of the researchers. In addition, the athletes overestimated their body height. Consequently, BMI calculated from self-report was biased in both women and men, with self-reports significantly lower than real BMI.

These discrepancies might be dependent on several factors. Upon arrival to the pre-race measurements, athletes were asked for both their body mass and body height. While some athletes may measure their body mass regularly, perhaps not all do. Most may rely upon measurements completed for official documents such as passports, where the time between that measurement and the actual measurement might have been considerable. Also, the timing of the measurements of stature might be of importance. Reilly, Tyrrell and Troup (1984) showed that body height was largest in the morning due to a distension of the body during the night. A significant circadian rhythm was observed, the trough to peak variation being 19.3 mm or 1.1% of overall stature. Since we measured the athletes the afternoon the day before race day, this might also explain the larger self-reported height[1]. In a male athlete with 75 kg body mass, 1.78 m body height and a body mass index of 23.67 kg/m^2, a change in body height of 1.06 mm would lead to a 0.01% increase in BMI. A change in body height of 0.08 mm would lead to a body mass index of 23.67 kg/m^2 with a 0.009% increase in BMI. These changes in body height would be well within the precision of the measurements and not clinically relevant.

Regarding body mass, these athletes measured their body mass most probably at home using their personal balance, which could be improperly standardized. Also, the aspect of age might give an explanation. Of the whole sample, 78.5% of the subjects were master athletes who are typically older than 35 years of age (Reaburn, & Dascombe, 2008).While data of female athletes did not differ between age groups, we found a significant underestimation of body mass and body mass index in male master athletes compared to younger athletes. Possibly these master athletes were not aware that with increasing age, body fat increases (Pollock, *et al.,* 1997). If they did not regularly measure their body mass, body fat may have

[1] Intervertebral discs undergo a significant strain after 1 hr of running (Dimitriadis, *et al.,* 2011). In contrast, side lying end-range lumbar flexion position results in a statistically significant mean spine height gain of 4.78 ± 4.01 mm while side lying mid-range lumbar flexion position results in a statistically significant mean spine height gain of 5.84 ± 4.4 mm (Gerke, Brismée, Sizer, Dedrick, & James, 2011). A significant increase in body height was recorded after both supine flexion and prone extension lying. The mean height gain was 3.11 mm using prone extension and 3.19 mm using the supine flexion protocol (Owens, *et al.,* 2009).

increased although they trained regularly (Pollock, *et al.,* 1997) thus leading to a higher body mass than expected. Presumably also these athletes felt they were training hard for a difficult event, and thus were motivated to perceive their athletic and physical capabilities as very high. That is, there may be a strong perceptual and motivational bias to believe they are in better condition, with more muscle, less fat, stronger, and taller than they really are.

A higher pre-race body mass might also be explained by pre-race hydration strategies (Maughan, & Shirreffs, 2008, 2010) where a high fluid consumption to hydrate may considerably increase body mass. Ingestion of supplements such as creatine might increase body mass. Several studies reported an increase in body mass and several of them reported an increase in lean body mass following creatine ingestion. This weight gain is most likely due to water retention in muscle but could also be due to some new muscle protein (Clarkson & Rawson, 1999). Pre-race carbohydrate loading increases muscular glycogen (Arnall, *et al.,* 2007; Bussau, Fairchild, Rao, Steele, & Fournier, 2002) which may lead to an increase in body mass. Pre-race training should not lead to major changes in body mass (Ball, Nolan, & Wheeler, 2011).

Smaller athletes may tend to overestimate their heights, and heavier athletes may tend to underestimate their body mass. Overestimation of body height for men and underestimation of body mass for women has already been reported for non-athletic populations (Brener, Mcmanus, Galuska, Lowry, & Wechsler, 2003; Jacobsen, & DeBock, 2001). Female students were more likely to underreport their body weight than male students (Brener, Mcmanus, Galuska, Lowry, & Wechsler, 2003). Jacobson and DeBock (2001) reported that male college students overestimated their body height. In contrast, female college students underestimated their body mass. In this study, however, there was no correlation between the reported data and the difference between self-reported and measured data. The smaller athletes did not tend to overestimate their body size and the heavier athletes did not tend to underestimate their body mass.

Limitations and Practical Applications

This study is limited in that body height was not measured in all races at the same time of day (Reilly, Tyrrell, & Troup, 1984). The groups of swimmers, cyclists, runners and skaters were not of the same size. Although there were differences between estimated and measured values for body mass, body height and body mass index, the underestimation of 0.4 kg/m^2 in body mass index would have a negligible influence on performance. The differences of 0.9 kg in body mass, 0.4 cm in body height, and 0.4 kg/m^2 in body mass index (and the corresponding effect sizes) were within the range of normal daily variation, and for body height even within the precision of the measurement (0.5 cm).

Conclusion

Estimation of body mass index from self-report of body mass and body height of endurance athletes for use as a predictor variable for endurance performance may result in significant errors. Researchers of anthropometric investigations in large field studies need to use standardized, objective measures. Investigators involved in anthropometric studies must be aware that especially male master athletes tend to underestimate their body mass and overestimate their body height thus leading to significant differences between estimated and measured body mass index and misclassification by WHO standards. However, given the small effect sizes, body mass and body height reported by endurance athletes were reasonably comparable to data measured by researchers.

REFERENCES

Aagaard, P., Sahlen, A., & Braunschweig, F. (2012). Performance trends and cardiac biomarkers in a 30-km cross-country race 1993-2007. *Medicine and Science in Sports and Exercise*, *44,* 894-899.

Arnall, D. A., Nelson, A. G., Quigley, J., Lex S., Dehart, T., & Fortune, P. (2007). Supercompensated glycogen loads persist 5 days in resting trained cyclists. *European Journal of Applied Physiology, 99,* 251-256.

Arrese, A. L., & Ostáriz, E. S. (2006). Skinfold thicknesses associated with distance running performance in highly trained runners. *Journal of Sports Sciences, 24,* 69-76.

Bale, P., Bradbury, D., & Colley, E. (1986). Anthropometric and training variables related to 10km running performance. *British Journal of Sports Medicine, 20,* 170-173.

Ball, N., Nolan, E., & Wheeler, K. (2011). Anthropometrical, physiological, and tracked power profiles of elite taekwondo athletes 9 weeks before the Olympic competition phase. *Journal of Strength and Conditioning Research, 25,* 2752-2763.

Barandun, U., Knechtle, B., Knechtle, P., Klipstein, A., Rüst, C.A., Rosemann, T., & Lepers, R. (2012). Running speed during training and percent body fat predict race time in recreational male marathoners. *Open Access Journal of Sports Medicine, 3,* 51-58.

Boström, G., Diderichsen, F. (1997). Socioeconomic differentials in misclassification of height, weight and body mass index based on questionnaire data. *International Journal of Epidemiology, 26,* 860-866.

Brener, N.D., Mcmanus, T., Galuska, D.A., Lowry, R., Wechsler, H. (2003). Reliability and validity of self-reported height and weight among high school students. *The Journal of Adolescent Health, 32,* 281-287.

Bussau, V. A., Fairchild, T. J., Rao, A., Steele, P., & Fournier, P. A. (2002). Carbohydrate loading in human muscle: an improved 1 day protocol. *European Journal of Applied Physiology, 87,* 290-295.

Clarkson, P. M., & Rawson, E. S. (1999). Nutritional supplements to increase muscle mass. *Critical Reviews in Food Science and Nutrition, 39,* 317-328.

Dimitriadis, A. T., Papagelopoulos, P. J., Smith, F. W., Mavrogenis, A. F., Pope, M. H., Karantanas, A. H., Hadjipavlou, A. G., & Katonis, P. G. (2011). Intervertebral disc changes after 1 h of running: a study on athletes. *The Journal of International Medical Research, 39,* 569-579.

Gerke, D. A., Brismée, J. M., Sizer, P. S., Dedrick, G. S., & James, C. R. (2011). Change in spine height measurements following sustained mid-range and end-range flexion of the lumbar spine. *Applied Ergonomics, 42,* 331-336.

Gianoli, D., Knechtle, B., Knechtle, P., Barandun, U., Rüst, C.A., & Rosemann, T. (2012). Comparison between recreational male Ironman triathletes and marathon runners. *Perceptual and Motor Skills, 115,* 283-299.

Hagen, R. D., Upton, S. J., Duncan, J. J., & Gettman, L. R. (1987). Marathon performance in relation to maximal aerobic power and training indices. *British Journal of Sports Medicine, 21,* 3-7.

Hoffman, M. D. (2008). Anthropometric characteristics of ultramarathoners. *International Journal of Sports Medicine, 29,* 808-811.

Hoffman, M. D., Lebus, D. K., Ganong, A. C., Casazza, G. A., & Van Loan, M. (2010). Body composition of 161-km ultramarathoners. *International Journal of Sports Medicine, 31,* 106-109.

Hoffman, M. D., & Fogard, K. (2001). Factors related to successful completion of a 161-km ultramarathon. *International Journal of Sports Physiology and Performance, 6,* 25-37.

Jacobson, B.H., & DeBock, D.H. (2001) Comparison of Body Mass Index by self-reported versus measured height and weight. *Perceptual and Motor Skills,* 92, 128-132.

Kenney, W. L., & Hodgson, J. L. (1985). Variables predictive of performance in elite middle-distance runners. *British Journal of Sports Medicine, 19,* 207-209.

Knechtle, B., Baumann, B., Knechtle, P., & Rosemann, T. (2010a). Speed during training and anthropometric measures in relation to race performance by male and female open-water ultra-endurance swimmers. *Perceptual and Motor Skills, 111,* 463-474.

Knechtle, B., Duff, B., Schulze, I., Rosemann, T., & Senn, O. (2009c). Anthropometry and pre-race experience of finishers and nonfinishers in a multistage ultra-endurance run--Deutschlandlauf 2007. *Perceptual and Motor Skills, 109,* 105-118.

Knechtle, B., Duff, B., Welzel, U., & Kohler, G. (2009a). Body mass and circumference of upper arm are associated with race performance in ultraendurance runners in a multistage race--the Isarrun 2006. *Research Quarterly for Exercise and Sport, 80,* 262-268.

Knechtle, B., Knechtle, P., Andonie, J.L., & Kohler, G. (2007). Influence of anthropometry on race performance in extreme endurance triathletes: World Challenge Deca Iron Triathlon 2006. *British Journal of Sports Medicine, 41,* 644-648.

Knechtle, B, Knechtle, P, Barandun, U, & Rosemann, T. (2011f). Anthropometric and training variables related to half-marathon running performance in recreational female runners. *The Physician and Sportsmedicine, 39,*158-166.

Knechtle, B., Knechtle, P., Barandun, U., Rosemann, T., & Lepers, R. (2011b). Predictor variables for half marathon race time in recreational female runners. *Clinics (Sao Paulo), 66,* 287-291.

Knechtle, B., Knechtle, P., Rosemann, T., & Lepers, R. (2010e). Predictor variables for a 100-km race time in male ultra-marathoners. *Perceptual and Motor Skills, 111,* 681-693.

Knechtle, B., Knechtle, P., Rosemann, T., & Lepers, R. (2011h). Personal best marathon time and longest training run, not anthropometry, predict performance in recreational 24-hour ultrarunners. *Journal of Strength and Conditioning Research, 25,* 2212-2218.

Knechtle, B., Knechtle, P., Rosemann, T., & Senn, O. (2011e). Personal best time and training volume, not anthropometry, is related to race performance in the 'Swiss Bike Masters' mountain bike ultramarathon. *Journal of Strength and Conditioning Research, 25,* 1312-1317.

Knechtle, B., Knechtle, P., Rosemann, T., & Senn, O. (2011c). What is associated with race performance in male 100-km ultra-marathoners--anthropometry, training or marathon best time? *Journal of Sports Sciences, 29,* 571-577.

Knechtle, B., Knechtle, P., Rosemann, T., & Senn, O. (2011g). Personal best time, not anthropometry or training volume, is associated with total race time in a triple iron triathlon. *Journal of Strength and Conditioning Research, 25,* 1142-1150.

Knechtle, B., Knechtle, P., Rüst, C. A., & Rosemann, T. (2011d). A comparison of anthropometric and training characteristics of Ironman triathletes and Triple Iron ultra-triathletes. *Journal of Sports Sciences, 29,* 1373-1380.

Knechtle, B., Knechtle, P., Rüst, C. A., & Rosemann, T. (2011i). Leg skinfold thicknesses and race performance in male 24-hour ultra-marathoners. *Proceedings* (*Baylor University Medical Center), 24,* 110-114.

Knechtle, B., Knechtle, P., Rüst, C. A., Rosemann, T., & Lepers, R. (2011j). Finishers and nonfinishers in the 'Swiss Cycling Marathon ' to qualify for the 'Race across America'. *Journal of Strength and Conditioning Research, 25,* 3257-3263.

Knechtle, B., Knechtle, P., Rüst, C. A., Senn, O., Rosemann, T., & Lepers, R. (2011a). Predictor variables of performance in recreational male long-distance inline skaters. *Journal of Sports Sciences, 29,* 959-966.

Knechtle, B., Knechtle, P., Schulze, I., & Kohler, G. (2008). Upper arm circumference is associated with race performance in ultra-endurance runners. *British Journal of Sports Medicine, 42,* 295-299.

Knechtle, B., Wirth, A., Baumann, B., Knechtle, P., Rosemann, T., & Oliver, S. (2010b). Differential correlations between anthropometry, training volume, and performance in male and female Ironman triathletes. *Journal of Strength and Conditioning Research, 24,* 2785-2793.

Knechtle, B., Wirth, A., Knechtle, P., & Rosemann, T. (2009b). Moderate association of anthropometry, but not training volume, with race performance in male ultraendurance cyclists. *Research Quarterly for Exercise and Sport, 80,* 563-568.

Knechtle, B., Wirth, A., Knechtle, P., & Rosemann, T. (2010d). Training volume and personal best time in marathon, not anthropometric parameters, are associated with performance in male 100-km ultrarunners. *Journal of Strength and Conditioning Research, 24,* 604-609.

Knechtle, B., Wirth, A., Knechtle, P., Zimmermann, K., & Kohler, G. (2009d). Personal best marathon performance is associated with performance in a 24-h run and not anthropometry or training volume. *British Journal of Sports Medicine, 43,* 836-839.

Knechtle, B., Wirth, A., & Rosemann, T. (2010c). Predictors of race time in male ironman triathletes: physical characteristics, training, or prerace experience? *Perceptual and Motor Skills, 111,* 437-446.

Maughan, R. J., & Shirreffs, S. M. (2008). Development of individual hydration strategies for athletes. *International Journal of Sport Nutrition and Exercise Metabolism, 18,* 457-472.

Maughan, R. J., & Shirreffs, S. M. (2010). Dehydration and rehydration in competitive sport. *Scandinavian Journal of Medicine and Science* in *Sports, 20,* 40-47.

Owens, S. C., Brismée, J. M., Pennell, P. N., Dedrick, G. S., Sizer, P. S., & James, C. R. (2009). Changes in spinal height following sustained lumbar flexion and extension postures: a clinical measure of intervertebral disc hydration using stadiometry. *Journal of Manipulative and Physiological Therapeutics, 32,* 358-363.

Pollock, M. L., Mengelkoch, L. J., Graves, J. E., Lowenthal, D. T., Limacher, M. C., Foster, C., & Wilmore, J. H. (1997). Twenty-year follow-up of aerobic power and body composition of older track athletes. *Journal of Applied Physiology, 82,* 1508-1516.

Reaburn, P., & Dascombe, B. (2008). Endurance performance in masters athletes. *European Review of Aging and Physical Activity, 5,* 31-42.

Reilly, T., Tyrrell, A., & Troup, J. D. (1984). Circadian variation in human stature. *Chronobiology International, 1,* 121-126.

Rüst, C.A., Knechtle, B., Knechtle, P., Barandun, U., Lepers, R., & Rosemann, T. (2011). Predictor variables for a half marathon race time in recreational male runners. *Open Access Journal of Sports Medicine, 2,* 113-119.

Schmid, W., Knechtle, B., Knechtle, P., Barandun, U., Rüst, C.A., Rosemann, T., & Lepers, R. (2012). Predictor variables for marathon race time in recreational female runners. *Asian Journal of Sports Medicine, 3,* 90-98.

Yoshimura, N., Kinoshita, H., Takijiri, T., Oka, H., Muraki, S., Mabuchi, A., Kawaguchi, H., Nakamura, K., & Nakamura, T. (2008). Association between height loss and bone loss, cumulative incidence of vertebral fractures and future quality of life: the Miyama study. *Osteoporosis International, 19,* 21-28.

Zillmann, T., Knechtle, B., Rüst, C.A., Knechtle, P., Rosemann, T., & Lepers, R. (2013). Comparison of training and anthropometric characteristics between recreational male half-marathoners and marathoners. *Chinese Journal of Physiology,* in press, DOI: 10.4077/CJP.2013.BAB105

Accepted October 24, 2012.

TABLE 1. Age of athletes by sport

Sex and Sport	*n*	Age, yr.	
		M	*SD*
Men			
Swimming	46	38.2	9.0
Cycling	228	42.0	8.4
Running	709	44.5	10.4
Triathlon	283	41.0	8.1
Inline	92	40.7	10.2
	1,358	42.9	9.8
Women			
Swimming	23	38.2	10.5
Cycling	2	40.0	8.5
Running	148	40.6	9.8
Triathlon	67	38.1	7.3
Inline	20	36.6	9.8
	260	39.4	9.3

TABLE 2. Comparison between data reported women and men of different endurance sport disciplines and data measured by researchers

Sex and Sport	*n*	BM_R, kg		BM_M, kg		Difference, kg		Cohen's *d*	ICC
		M	*SD*	*M*	*SD*	*M*	*SD*		
Men									
Swimming	46	82.5	10.1	83.4	9.6	-0.9*	2.1	-0.09	0.98
Cycling	228	75.7	8.3	76.7	8.4	-1.0*	1.6	-0.12	0.98
Running	709	73.9	8.3	74.7	8.6	-0.8*	2.0	-0.09	0.97
Triathlon	283	76.0	8.3	77.0	8.5	-1.0*	1.8	-0.12	0.98
Inline	92	76.5	9.6	77.1	9.8	-0.6*	1.3	-0.06	0.99
		75.1	8.7	76.0	8.8	-0.9*	1.9	-0.10	0.98
Women									
Swimming	23	68.4	7.3	69.5	6.8	-1.1*	1.3	-0.16	0.98
Cycling	2	58.5	6.4	58.8	6.4	-0.3*	0.1	-0.05	0.98
Running	148	58.9	7.4	59.7	7.7	-0.8*	1.6	-0.11	0.98
Triathlon	67	59.1	6.5	60.1	6.5	-1.0*	1.2	-0.15	0.98
Inline	20	60.5	6.4	60.9	6.6	-0.4	1.1	-0.06	0.97
Mean ± SD		59.9	7.6	60.8	7.7	-0.9*	1.4	-0.12	0.98

Note.- BM_R = body mass reported by athletes; BM_M = body mass measured by researchers; Diff = difference between data reported by athletes and data measured by researchers; * $p < .05$; *d* = Cohen's *d* effect size metric; ICC = Intraclass correlation coefficient.

TABLE 3. Comparison between data reported women and men of different endurance sport disciplines and data measured by researchers

Sex and Sport	(*n*)	BH_R, cm		BH_M, cm		Difference, cm		*d*	ICC
		M	*SD*	*M*	*SD*	*M*	*SD*		
Men									
Swimming	46	181.3	6.5	181.8	6.7	0.5*	0.9	0.08	0.99
Cycling	228	179.4	6.9	179.9	6.8	-0.5*	1.3	-0.07	0.99
Running	709	178.4	6.6	178.1	6.7	0.3*	0.1	0.05	0.99
Triathlon	283	179.5	6.5	179.3	6.5	0.2*, #	1.0	0.03	0.99
Inline	92	179.2	6.9	178.5	7.1	0.7*	1.3	0.01	0.98
		178.9	6.7	178.6	6.7	0.3*	1.1	0.05	0.99
Women									
Swimming	23	168.0	4.8	167.2	4.9	0.8*	0.7	0.16	0.99
Cycling	2	170.0	4.2	170.0	4.2	0.0	0.0	0.00	1.00
Running	148	166.9	6.5	166.3	6.6	0.6*	1.3	0.09	0.98
Triathlon	67	167.6	6.4	167.7	6.4	-0.1*, ##	0.7	-0.02	0.99
Inline	20	167.3	5.7	166.6	5.7	0.7*	1.6	0.12	0.96
		167.2	6.3	166.8	6.3	0.5*	1.2	0.06	0.98

Note.- BH_R = body height reported by athletes; BH_M = body height measured by researchers; Diff = difference between data reported by athletes and data measured by researchers; * = $p < .05$; # = statistically difference ($p < .05$) of male triathletes compared with cyclists, runners and inline skaters; ## = statistically difference ($p < .05$) of female triathletes compared with runners and swimmers; *d* = Cohen's *d* effect size metric; ICC = Intraclass correlation coefficient.

TABLE 4

Comparison between data reported women and men of different endurance sport disciplines and data measured by researchers

Sex and Sport	n	BMI_R, kg/m^2		BMI_M, kg/m^2		Difference, kg/m^2		d	ICC
		M	*SD*	*M*	*SD*	*M*	*SD*		
Men									
Swimming	46	25.1	2.5	25.5	2.5	-0.4*	0.7	-0.16	0.96
Cycling	228	23.5	2.1	23.9	2.2	-0.4*	0.6	-0.19	0.96
Running	709	23.2	2.1	23.5	2.2	-0.3*	0.7	-0.14	0.94
Triathlon	283	23.6	2.1	23.9	2.1	-0.3*	0.6	-0.14	0.96
Inline	92	23.8	2.4	24.2	2.5	-0.4*	0.5	-0.16	0.98
Mean ± *SD*		23.4	2.1	23.8	2.2	-0.4*	0.7	-0.23	0.96
Women									
Swimming	23	24.2	2.3	24.9	2.1	-0.7*	0.5	-0.31	0.98
Cycling	2	20.2	1.2	20.3	1.2	-0.1	0.0	0.00	1.00
Running	148	21.1	2.0	21.5	2.1	-0.4*	0.7	-0.20	0.95
Triathlon	67	21.0	2.0	21.4	2.0	-0.4*	0.5	-0.20	0.97
Inline	20	21.6	1.9	22.0	2.0	-0.4*	0.7	-0.21	0.94
Mean ± *SD*		21.4	2.2	21.8	2.3	-0.4*	0.6	-0.18	0.97

Note.- BMI_R = body mass index reported by athletes; BMI_M = body mass index measured by researchers; Diff = difference between data reported by athletes and data measured by researchers; * = $p < .05$; d = Cohen's d effect size metric; ICC = Intraclass correlation coefficient.

TABLE 5

Distribution of women and following the international classification of body mass index (BMI) of the World Health Organization (WHO)

Range	BMI, kg/m^2	Men					Women					W-M
		Reported		Measured		Diff	Reported		Measured		Diff	Diff
		n	%	*n*	%	%	*n*	%	*n*	%	%	%
Underweight	< 18.5	2	0.1	2	0.1#	0.0	17	6.7	12	4.7	2.0	4.6†
Normal weight	18.6 – 24.9	1,087	80.4	997	73.7*	6.7#	224	87.8	223	87.5	0.3	14.0†
Overweight	25.0 – 29.9	250	18.5	336	24.9*	6.4#	13	5.1	19	7.5	2.4	-17.4†
Obese I	30.0 – 34.9	13	1.0	16	1.2	0.2	1	0.4	1	0.4	0.0	-0.8
Obese II	> 35.0	-	-	1	0.1	0.1	0	-	-	-	-	-0.1
Total		1,352	100	1,352	100	13.4#	255	100	255	100	4.7	

Note.- Diff: differences between data reported by athletes and data measured by researchers in %; W-M: Differences of % between the amount of women and men in each range of the body mass index classification. * Statistical significance ($p < .05$) in males between normal weight and overweight groups comparing data reported by athletes and measured by researchers. # Statistical significance ($p < .05$) between males and females groups when the difference between reported data and measured data was analyzed in the normal and overweight groups. † Statistical significance ($p < .05$) between the percentage of males and females in each range.